

# Effectiveness of the GT200 Molecular Detector: A Double-Blind Test

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## Abstract

The GT200 is a device that has been extensively used by the Mexican armed forces to remotely detect and identify substances such as drugs and explosives. A double blind experiment has been performed to test its efficacy. In seventeen out of twenty attempts, the GT200 failed in the hands of certified operators to find more than 1600 amphetamine pills and four bullets hidden in a randomly chosen cardboard box out of eight identical boxes distributed within a 90m×20m ballroom. This result is compatible with the 1/8 probability expected for a completely ineffectual device, and is incompatible with even a moderately effective working one.

## 1 Introduction

The GT200 is sold as a *remote substance detector* that is claimed by its manufacturer, UK-based Global Technical Ltd, to detect and identify various substances including explosives and drugs in tiny quantities, as small as picograms, and at distances as large as 5km [1]. According to official documents obtained through the *Mexican Federal Access to Information Institute* (IFAI, for its acronym in Spanish), and from the web portals of several government agencies [2], the Mexican Government has bought more than 940 of these devices at prices that fluctuate from around \$280,000MX to \$580,000MX Mexican pesos (the current exchange rate fluctuates around \$13MX for \$1USD). Its main users are the

Mexican Army and Navy, with more than 742 and 102 units respectively, followed by the state petroleum company (PEMEX) with 54 units. According to press releases [3], the GT200 has been used successfully in hundreds of searches for cocaine, marijuana, amphetamines, and several other substances. It is not uncommon to find the GT200 in use at military checkpoints and at airports, and it has been used to justify house searches and detentions of an unknown number of citizens for the supposedly possession and trafficking of illegal substances. Nevertheless, the GT200 is one of a class of detectors based on dowsing rods with brand names such as *Quadro Tracker*, *DKL-Lifeguard*, *Mole*, *Sniffex*, *ADE651*... which have invariably failed in controlled experiments [4, 5]. In July, 2012, the manufacturer of the GT200, Gary Bolton, was charged in the United Kingdom for dishonestly representing the GT200 as capable of detecting explosives [6] and his case is currently in court. In Mexico, the National Committee of Human Rights issued a recommendation [7] against the use of the GT200, as the number of illegal searches by the police and armed forces increased dramatically since it was adopted, and its use would constitute a violation of human rights, even if it were functional, as it would violate the right to privacy. Currently, the Supreme Court is reviewing the use of the GT200 to provide *evidence*.

One of us (WLM) has participated as expert witness in a judicial trial where the GT200 provided multiple evidences of drug and munition possession. As part of their judicial *statements*, the operators of the GT200 stated the *theory of operation of the apparatus* [8]. It is claimed that the apparatus is sensitive to *diamagnetic and paramagnetic fields* that are produced by all substances and which are characteristic of each, allowing their remote detection and identification, and that the cards that are used to program the equipment are fed by electrostatic energy produced by the operator, among many other statements filled with pseudo-scientific jargon. WLM was asked to write a detailed criticism of this theory [9], concluding that

*it contains numerous conceptual errors and meaningless statements that use scientific language but out of context. Those statements that do have meaning are false and describe the workings of an apparatus that is not compatible with current scientific knowledge. Thus, it is certain that the equipment does not work as stated by its technical specifications sheet. Furthermore, technical arguments yield strong doubts that there is any mechanism whatsoever that would allow the device to function and to detect the substances that it supposedly detects. The only way to obtain certainty would be through a double blind test.*

This study was used in a different judicial trial to free a man that had been accused of drug trafficking [10]. It has also been discussed within the Mexican Senate [11, 12], which exhorted the Head of the Executive Branch of the Government of Mexico to evaluate scientifically the efficacy of the GT200 [13]; the President has not complied yet.

Another one of us (AR) has participated as expert witness in yet another trial and asked to determine the validity of the evidence provided through the use of the GT200. In this case the judge ordered the Army to participate in a scientific test, to be conducted by AR, providing a GT200 apparatus, an expert operator and enough quantity of a substance to be detectable. It is interesting to note that the Army had previously rejected an offer by Arturo Menchaca, former president of the Mexican Academy of Science (Academia Mexicana de Ciencias, AMC) to develop a protocol and supervise a scientific test. The reason for rejection was the legal obligation to comply with the terms of the commercial contract signed upon purchase of the detectors (fragments of the corresponding letters are displayed in [11]). AR invited WLM to participate in the test, which was carried out in October 21, 2011 in the grounds of the Mexican Academy of Science. Being part of a trial in progress, we had not made public the results of the test. Nevertheless, about a year after the test, the main results were obtained and released to the public by a national newspaper [14]. Thus, we believe there is no longer a reason to keep the information private. The purpose of this article is to describe the test and its results. The paper is organized as follows. In Sec. 2 we describe the protocol designed for the test and in Sec. 3 the actual test. We incorporate many details which may be safely overlooked by the reader, but which may be of interest to those involved in similar tests and which might have some historical value. The results we obtained are analyzed in Sec. 4, and we devote Sec. 5 to our conclusions.

## 2 Protocol

The test would take place at an abandoned 90m×20m ballroom (Fig. 1) within the grounds of the Mexican Academy of Sciences. Two members of the army would be designated by the commander of the 24th military zone in the state of Morelos to participate as experts in the use, operation and care of the GT200 molecular detector. They would provide sufficient quantities of any substance that is expected to be detectable by the GT200. Two experimenters (AR and WLM) would also participate.

### 2.1 Settings

All the participants would meet at a specified office to identify themselves and to receive an explanation of the procedures. They would be divided into a hide ( $H$ ) and a search ( $S$ ) team, each with one soldier and one experimenter. All members of each team would stay together for the duration of the whole test. Up to two witnesses would also be allowed within each team. Two video-cameras would be positioned within the ballroom and facing each other to monitor continuously its two entrances. The experimenters would also be provided with hand-held cameras to film in detail the actions of the soldier of his corresponding team. To eliminate the possibility of communication between soldiers during the test, they would leave all their belongings in bags that would remain at the



Figure 1: Aerial view of part of the grounds of the Mexican Academy of Sciences, including the abandoned ballroom where the test took place. Its principal entrance and the annex with the secondary entrance are shown. As reference to illustrate the scale, the auditorium and the old dog race track, now used as a parking lot, are also shown. The image is taken from *googlemaps*.

AMC offices. Furthermore, the participants would be scanned by a detector of electromagnetic waves to discard the presence of transmission devices. The experimenters would keep notes to elaborate a journal in which the soldiers would sign their agreement. The GT200 would be operated exclusively by the soldier of the  $S$  team. The substance to be hidden and the boxes which would hide them would be manipulated exclusively by the soldier of the  $H$  team.

Eight opaque cardboard boxes would be used, labeled  $AAA$ ,  $AAS$ ,  $ASA$ ...  $SSS$ . After being examined by the participants, the sample would be placed within a container, to avoid contaminating the boxes and the room. The experimenters would explain to all participants that the sample would be hidden within one box and that a search for it would be performed with the detector.

Each box would be inspected by the soldier of the  $H$  team to verify that it is empty and that it is appropriate for the test. Then he would place each box within the room at the position of his own choice, making sure that there is enough space between them to allow detection of the substance if it were in any box, and allowing the triangulation and all motions required for the successful operation of the device. Marks would be made in the floor to identify the position of each box which would not be moved during the rest of the test. The orientation of the lids of the boxes would be marked and they would not be modified during the rest of the test. The lids would have to be properly closed on their corresponding boxes.

The soldiers would be asked for objections to the testing procedure and its conditions; if they were to consider that the conditions were adequate for the test, it would proceed. Otherwise, the test would be finished yielding as a result that the GT200 is unable to detect the sample under the stated conditions. In

any case, the soldiers would sign a document stating their decision at this point.

## 2.2 Experiment

The test would consist on two iterated series of runs. All participants would remain silent during each run except for procedural clarifications. No interruption would be allowed before the ongoing run were to finish completely. The experimenters would be allowed to invalidate any run if they consider it violated the protocol, in which case, it would be repeated and the incident reported.

### 2.2.1 First Series: Calibration

The soldier of the  $H$  team would hide the sample in the box labeled  $AAA$ . Then, the soldier in the  $S$  team would search for it with the GT200, and write down the identity  $xyz$  of the box picked out by the detector in a specially prepared sheet. The exercises would be repeated for the remaining boxes  $AAS$ ,  $ASA$ ... $SSS$ . The participants would verify and sign the results sheet.

### 2.2.2 Second Series: Test

1. The  $S$  team would abandon the ballroom and proceed to a waiting room within an annex (Fig. 1). Nobody would remain in the ballroom but the members of the  $H$  team.
2. Through a random process, the experimenter  $E_H$  of the  $H$  team would assign one of the eight labels to each of the boxes, and the soldier  $S_H$  would place a paper sheet with the corresponding label *inside* the designated box and close it firmly.
3.  $E_H$  would toss a coin three times and record the three results  $xyz$  in a second form. In México, the result of a coin toss is either *Águila* or *Sol*, the equivalent of *Heads* and *Tails* in the US. Thus,  $x, y, z = A$  or  $S$  if the corresponding result were *Águila* or *Sol*. Both  $S_H$  and  $E_H$  would sign the corresponding row of the form. The soldier would place the sample within the box labeled  $xyz$  and after checking that all boxes are firmly closed, the  $H$  team would abandon the ballroom through its main entrance.
4.  $E_H$  would knock on the door of the waiting room, where after a minute, the  $H$  team would enter and stay, allowing the  $S$  team time to leave the waiting room and to enter the ballroom from the annex through a second lateral entrance. Thus, the members of both teams would not talk nor see each other.
5. The soldier  $S_S$  of the  $S$  team would use the GT200 to identify the box containing the sample, and, without opening it, would place an indicator on top of its lid. Then, the  $S$  team would leave the ballroom through its main entrance.

6. The experimenter  $E_S$  of the  $S$  team would knock on the door of the waiting room into which the  $S$  team would enter after a minute, giving time to the  $H$  team time to leave the room and enter the ballroom through the lateral entrance.
7.  $S_H$  would identify and record in a third form the label corresponding to the box that had been selected by  $S_S$  using the GT200 as that containing the sample. The corresponding row would be signed by  $S_H$  and  $E_H$ .
8.  $S_H$  and  $S_S$  were not to communicate any information about the box labeling, the placement of the sample nor the ongoing results of the test.
9. If the run were to be invalidated, a mark would be placed to that effect in the three forms.
10. If the test were to be interrupted for any kind of personal reasons, it would only be done at this stage.
11. The cycle starting at step 3 would be repeated until 20 valid runs were accumulated.
12. The results would be written out to a fourth form where successes and failures would be tallied. All the participants would check the transcript for consistency with the data contained in the other forms and, when satisfied, would write down their name and sign.

### 2.2.3 Statistical Analysis

The results would be analyzed from a statistical viewpoint to determine the efficacy of the GT200.

## 2.3 Remarks

The main problems we attempted to solve with this protocol were those derived from the expected distrust among the participants in the test. The possibility of information exchange that would give the soldier in the  $H$  team knowledge about the identity of the box where the soldier in the  $S$  team hid the substance had to be minimized. With eight boxes it would have been enough to exchange a mere three bits of information. It was also necessary to minimize the possibility of common excuses in the case of a failure, such as accusing the experimenters of contaminating the boxes. Furthermore, we expected the soldiers to distrust the experimenters and it was important to convince them that no foul play would take place.

The number of boxes was chosen as  $8 = 2^3$ , so that three coin tosses would select a box randomly. The number of trials was chosen as 20, so that the probability of success in more than half of the trials would be less than  $10^{-4}$  if the GT200 were as good as chance, as well as the probability of failure in more

than half the trials were the detector moderately efficient, with a probability of success of 85% in an individual run. Thus, success or failure would be definite.

The purpose of the calibration series, which we expected to be successful, was to eliminate excuses were the test to fail, as the conditions during both series of detection trials would be essentially identical.

### 3 Test

The test took place on Oct. 21, 2011 at the premises of the Mexican Academy of Sciences. Two Ministerial Policemen were in custody of part of the sample consisting of 1630 30mg capsules of *Itrabil* and 33 30mg capsules of *Obeclox*, both with the substance *Clorobenzorex*, a stimulant drug of the phenethylamine and amphetamine chemical families. The rest of the sample consisted of 3 9mm×19mm bullets and one 0.28" bullet, whose custody was in charge of two soldiers, a Lieutenant Colonel and a Sergeant 2nd Class. The sample had purportedly been detected using the GT200 and later confiscated from the house of the defendant.

The operators of the GT200 were the Lieutenant Saulo Pérez-Lozano (SPL) and the Sublieutenant Bernabé Reyes-Pérez (BRP). The Lawyer María Elena Gómez-Salgado (MEGS) and the Sergeant 2nd Class Jonathan Juárez-Ibarra (JJI) witnessed the test, which was conducted by AR and WLM. Two fixed video-cameras were set up in opposite sides of the room and filmed the whole test. Two hand-held cameras were operated by the experimenters and filmed parts of the test [15].

The operators of the GT200 were judged to be fully confident in the capabilities of the device before the test began. Thus, the experimenters judged subjectively that they would not attempt to cheat, and they were not scanned for electronic devices after they were asked to leave behind their belongings. A simple inspection of their pockets revealed they were empty.

After receiving an explanation of the procedures, the ballroom where the test would be conducted was examined. At first, SPL worried about the neighboring houses; he wanted to rule out the possibility of their occupants being sick and taking medicine, as that could confuse the detector, which might link energetically with a substance outside the premises. Nevertheless, he decided the room allowed the boxes to be placed far enough from the walls to minimize the effects of neighboring houses. On the other hands, he asked that a table with coffee and soft drinks be removed from the room. He also complained that the manila envelope that contained the bag of amphetamines smelled of marijuana, and thus, it would have contaminated the exterior of the bag, which in turn would contaminate the interior of the boxes. Although marijuana was not among the substances to detect, and the ministerial policemen stated that the envelope was brand new and denied that it had never been in contact with marijuana or any similar substance, it was decided to place the sealed bags with the pills and the bullets within a clean clear plastic bag and to close it tightly. The experimenters convinced SPL that although the interior of the bag might

get contaminated, its exterior would remain clean and unable to contaminate the boxes. Thus, he agreed that the test could proceed. Figure 2 shows the agreement signed by the soldiers, which translated reads

*The undersigned certify that we have received an explanation of the protocol through which the GT200 will be tested. We have understood the explanation and we state that the conditions under which the test will take place don't hinder the adequate operation of the GT200 molecular detector. In particular, we believe the GT200 should be capable of detecting the sample, consisting of*

- 1. 1630 capsules of Itrabil 30mg containing Clorobenzorex,*
- 2. 33 capsules of Obeclox 30mg containing Clorobenzorex,*
- 3. 3 9×19mm bullets and one 0.380" bullet,*

*when hidden within a cardboard box such as those we have been shown and placed within the room where the test will be held. The size and conditions of the room, as well as the number of boxes to be employed, are adequate for the test. We understand that nobody but us is to manipulate the boxes, the molecular detector nor the sample.*

The soldiers decided that the GT200 would be operated by BRP. Thus, the members of the *H* team were AR as experimenter and SPL as soldier, and the members of the *S* team were WLM as experimenter and BRP as operator of the GT200. The *S* team was joined by MEGS and JJI as witnesses. The policemen and the lieutenant colonel that were in charge of the sample remained out of the ballroom and were asked not to talk to the team members while the test was in progress.

SPL was asked to place the boxes at the positions of his choice. He decided to place them along a straight line oriented from east-west, along the long side of the ballroom, at a distance of approximately 6m from each other and at a distance of 10m from the north and south walls (Figs. 1 and 3).

The calibration stage began at noon. SPL hid the sample in box AAA (the rightmost in Fig. 3) in plain view of all the participants. BRP searched it with the GT200 and after pacing a couple times the length of the area occupied by the boxes, the antenna of his GT200 repeatedly rotated 90° in front of box AAA, so that, after 5 minutes, he announced that the sample was located indeed in box AAA. This result was written down in the appropriate sheet (Fig. 4). The test proceeded successfully with box AAS, for which finding the sample took 4 minutes. Successful detection in box ASA took 5 minutes and after finishing, BRP said he couldn't go on. He told us that he was becoming very tired and that the GT200 stops working if its operator is fatigued. Not wanting to allow excuses for a possible failure, at the end of that run we interrupted the test and took a 7 minute break. After searching successfully for the sample in box ASS, a task that took another 7 minutes, BRP said it would be impossible to finish the test as planned. Considering that the second stage would be more important, and that the first stage had enough repetitions for its intended purpose, we



21 de octubre de 2011

Los abajo firmantes hacemos constar por medio de la presente que se nos ha explicado el protocolo mediante el cual se llevarán a cabo las pruebas al detector molecular GT200. Hemos entendido dicha explicación y manifestamos que las condiciones en las que se llevará a cabo la prueba no impiden la adecuada operación del detector molecular GT200. En particular, consideramos que el GT200 debe ser capaz de detectar la muestra consistente en

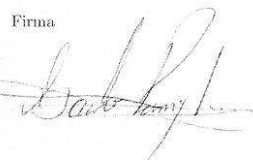
1. 1630 cápsulas de 30 mg. de Itrabil con la sustancia Clobenzorex.
2. 33 cápsulas de 30 mg. de Obeclox con la sustancia Clobenzorex.
3. 3 cartuchos calibre 9x19mm y un cartucho calibre 0,380"

cuando dicha sustancia se halle escondida en el interior de una caja de cartón como las nos han mostrado colocada en el suelo en el interior del salón designado para realizar la prueba. Las dimensiones y condiciones del salón y el número de cajas a ser empleadas son adecuadas para la realización de la prueba. Entendemos que nadie además de nosotros manipulará las cajas, el detector molecular ni la sustancia provista.

Nombre

Firma

Jose Saulo Perez Lozano



Humberto Barral Rojas Pérez



Figure 2: Agreement on the conditions of the test.

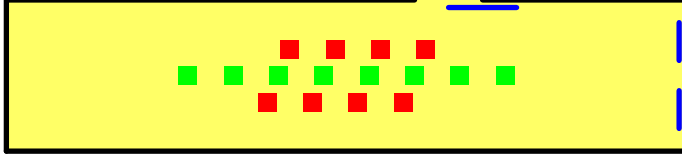


Figure 3: Schematic drawing of the ballroom, indicating the entrances and the position chosen for the boxes in the initial (green) and the last (red) part of the test.

Box Number	Labels			
	Phase 1	Phase 2	Phase 3	Phase 4
1	SAA	SSS	SAS	AAS
2	AAS	ASS	SSA	ASA
3	ASS	SAA	AAS	ASS
4	SAS	SSA	SSS	SAA
5	AAA	ASA	SAA	SSA
6	ASA	AAS	ASA	SSS
7	SSA	AAA	AAA	SAS
8	SSS	SAS	ASS	AAA

Table 1: Assignment of labels to boxes during the four phases of the double blind stage. The boxes were numbered from East to West (left to right in Fig. 3)

decided to conclude at this point the calibration stage. As shown in Fig. 4, the GT200 was able to correctly locate the sample in four out of four attempts. At this point the test was interrupted and we took a 10 minute break.

The *double blind* stage began at 12:41. The *S* team entered the waiting room while the *H* team entered the ballroom and drew randomly from a recipient a sequence of folded papers marked with the box labels to be assigned to the boxes. Thus, the first box counting from the entrance at the right towards the left in Fig. 3 was assigned the label *SAA*, the second *AAS*, the next boxes *ASS*, *SAS*, *AAA*, *ASA*, *SSA*, and finally, the eighth box was marked *SSS* (see table 1). SPL put each label inside of the corresponding box, so that they were not visible with the lid on. AR tossed a coin three times, obtaining *Águila* each time. Therefore, SPL put the sample in the box corresponding to the label *AAA*, the fifth counting from the entrance. The *H* team left the room and AR signaled the *S* team to start the search. After BRP picked out a box with his GT200, the *S* team left the room, the *H* team entered, identified the box supposedly containing the hidden substance and wrote down its label. The search took 11 minutes. Subsequent searches took 12, 6, 4 and 19 minutes. The results are summarized in fig. 5. While timing the searches was not considered in the protocol, their fluctuations, going from 4 up to 24 minutes are interesting, and they are summarized in Table 2. (Unfortunately, the times corresponding to

Llana M<sub>B</sub>

logu Rota

1 - SAA  
2 - AAS  
3 - SAA  
4 - ASA  
5 - AAA  
6 - ASS  
7 - SSA  
8 - SSS

1  
2  
3  
4  
5  
6  
7  
8

Tarjeta CA. Calibración						
Paso Válido	Contenedor			Designada		
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R' <sub>1</sub>	R' <sub>2</sub>	R' <sub>3</sub>
I.	A	A	A	A	A	A
II.	A	A	S	A	A	S
III.	A	S	A	A	S	A
IV.	A	S	S	A	S	S
V.	S	A	A			
VI.	S	A	S			
VII.	S	S	A			
VIII.	S	S	S			
IX.						
X.						
XI.						
XII.						
XIII.						
XIV.						
XV.						
XVI.						
XVII.						
XVIII.						
XIX.						
XX.						
Total de aciertos:						

AS

Nombres

Firmas

Eo Alejandro Ramirez.

AS

Mo Jose Saulo Perez Lozano

M<sub>B</sub>

Figura 1: CA

Figure 4: Results of the calibration stage of the test.

Number of Search	Starting Time	Ending Time	Duration (minutes)
I	12:45	12:56	11
II	13:18	13:30	12
III	13:38	13:44	6
IV	13:53	13:57	4
V	14:07	14:26	19
Lunch, swap, reshuffle			
VI	14:50	15:14	24
VII	15:20	15:28	8
VIII	15:36	15:44	8
Rest			
IX	15:59	16:06	7
X	16:12	16:25	13
Swap, reshuffle			
XI	16:40	16:46	6
XII	16:55	17:05	10
XIII	17:14	17:21	7
XIV	17:29	17:39	10
XV			
Swap, reshuffle			
XVI	18:03	18:11	7
XVII	18:17	18:25	8
XVIII	18:31	18:38	7
XIX	18:44	18:48	4
XX	18:56		

Table 2: Times taken for each search during the double-blind stage.

two of the three successful searches were not registered: after search XV due to distractions arising from the end of a stage and a discussion with the operator, and at the end of search XX due to the end of the test.) For comparison purposes, we also asked the soldier of the  $S$  team to flip a coin three times after each search and record the result, which was later transcribed into the results sheet, Fig. 4. By the end of the fifth iteration we took a lunch break.

During lunch, BRP complained that he was getting extremely tired and suggested that the test be extended for a few days. AR and WLM decided that, to comply with the judge’s orders, the test would have to be finished in only one day. To allow BRP some rest, WLM asked SPL if he would be able to operate the GT200. As it turned out that he was an even more experienced operator than BRP, it was decided to swap operators between the  $S$  and  $H$  teams at the end of each fifth run. Unfortunately, swapping operators allowed them to know the ongoing results of the test before it was completely finished, something that AR and WLM had wanted to avoid in order to comply fully

Tarjeta PA										
Paso	Contenedor			Volados			Aciertos	Búsqueda		
Válido	$R_1$	$R_2$	$R_3$	$R'_1$	$R'_2$	$R'_3$	(1 o 0)	$R''_1$	$R''_2$	$R''_3$
I.	A	A	A	A	S	A	0	A	S	S
II.	A	S	A	S	A	S	0	S	S	A
III.	S	S	A	S	A	A	0	A	S	A
IV.	A	S	A	A	A	S	0	A	A	S
V.	A	A	A	A	A	A	1	S	A	S
VI.	S	A	S	S	A	A	0	S	S	A
VII.	A	S	A	A	A	A	0	A	A	A
VIII.	A	A	S	A	A	A	0	A	A	S
IX.	S	A	A	A	S	S	0	S	S	A
X.	A	S	S	A	A	S	0	S	S	A
XI.	A	A	A	A	S	S	0	S	S	A
XII.	A	A	S	A	S	S	0	S	S	S
XIII.	A	S	S	S	S	S	0	A	S	A
XIV.	A	S	A	S	S	S	0	A	A	A
XV.	A	A	S	A	A	A	0	A	A	S
XVI.	S	S	S	A	A	S	0	S	S	A
XVII.	S	S	A	A	A	A	0	S	A	S
XVIII.	A	A	A	S	A	A	0	S	S	S
XIX.	A	S	S	A	A	A	0	A	A	A
XX.	S	A	A	A	S	S	0	S	A	A
Total de aciertos:							1 / 20	Total de aciertos:		
								3 / 20		





Nombre	Firma
José Sule Pérez Lozano	
HUMBERTO D REND PEREZ	
Alfredo Ramírez Solís	
Luis Mochán Bacha	

Figura 5: PA

Figure 5: Summary of the results. From left to right, the columns indicate the consecutive search number, the label of the box where the sample was actually hidden, a label chosen through three flips of a coin, number of correct hits, the label of the box picked out through a search with the GT200 and the number of correct hits.

with the double-blind character of the test. Furthermore, SPL decided that the disposition of the boxes should be changed to reduce the distance to walk during each search. AR and WLM agreed provided the new disposition would not hinder the efficacy of the detection. The new disposition was in a zig-zag pattern with approximately 6m between neighboring boxes, as shown in Fig. 3.

The labels were reshuffled (Table 1) and the second phase of the double blind stage began, with SPL in the *S* team and BRP in the *H* team. The test was resumed at 14:50 and the sixth search took 24 minutes. SPL being aware of the failure of the first five searches (Fig. 4), complained that the boxes might have been already contaminated by marijuana vapors from the manila envelope. WLM insisted this couldn't happen as the sample had been placed within a closed plastic bag. Furthermore, marijuana vapors shouldn't interfere with the test, as it was not the substance that was being searched for. It turned out that SPL had actually placed a card for marijuana within his GT200, besides one for amphetamines and another for munitions. He explained that the extra card enhanced the detecting power of the GT200. At the end of the seventh and eight iterations, SPL was sweating abundantly and he complained that the waiting room was one floor below the ballroom and that climbing steps left him agitated, hampering the efficacy of the search. WLM told him he could rest in the ballroom as long as he desired before starting each search and announced a fifteen min. break. After two more searches, taking 7 and 13 minutes respectively, the second phase was finished.

The pattern was repeated for two more phases, swapping of operators, reshuffling of box labels and five hide and search iterations. At the end of the third phase BRP complained that to be effective, the GT200 instruction manual indicates that complementary search methods should be used, such as a trained companion dog or a colleague to perform an exhaustive manual search. These arguments were dismissed by WLM, as it was the GT200, not the dog or a companion that was being tested. Furthermore, BRP believed that the GT200 was frequently picking up boxes that were contiguous to those actually containing the sample, and pointed out that the GT200 is not expected to point at the exact location of the sample, but only to the general area. WLM argued that the instruction manual, which he read during the test, stated that the uncertainty was of only 2m, which should have been good enough to identify the box containing the sample, as the boxes had been placed by the soldiers at the positions of their choice and with a large enough distance, at least 6m, between each other.

## 4 Results

As shown by Fig. 4, the GT200 pointed out to the correct location during the calibration stage in four times out of four attempts. This demonstrates that the GT200 was perfectly capable of finding the sample *when the operator knew beforehand the location where it had been hidden*. The probability of obtaining this result by chance only would have been  $(1/8)^4 \approx 0.00024$ , rather small. Thus,

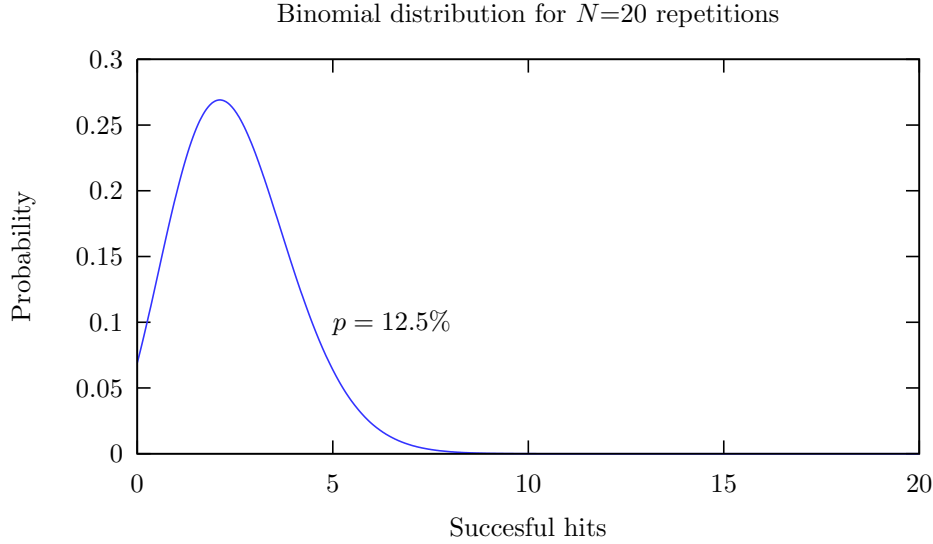


Figure 6: Binomial distribution showing the probability of different experimental outcomes for a completely random detector.

this stage also showed that the experimental conditions were adequate for the search of the provided sample and that detection was not being hindered by the kind of boxes employed, the envelopes and bags that contained the sample, the neighboring homes, the presence of the researchers and witnesses, the positioning of the boxes within the room, the walls of the room, the weather conditions nor by any other condition present during the test.

As shown by Fig. 5, during the double-blind stage, the operators of the GT200 were able to identify the correct box containing the sample in only three out of twenty attempts. This result is consistent with the binomial distribution

$$b(p, m, N) = \frac{N!}{m!(N-m)!} p^m (1-p)^{N-m} \quad (1)$$

that describes the probability of having  $m$  correct hits out of  $N$  attempts when the efficacy of the detector, i.e., its probability of success in any one run, is  $p$ . For a completely random case, the probability of a successful search when the sample is hidden in one out of eight boxes would be  $p = 1/8$ . The corresponding binomial distribution is illustrated in Fig. 6. It has an average of 2.5 and a standard deviation of 1.48, and therefore is completely consistent with the experimental result. The figure shows that in a random search the probability of having obtained  $m \geq 7$  hits would be negligible, more than three standard deviations away from the mean. In fact, the probability of less than 7 hits would be above 99%. The probability of having exactly 3 hits is  $b(1/8, 3, 20) = 23\%$ , very close to the maximum value. On the other hand, in Fig. 7 we show the corresponding distribution function corresponding to a moderately effective

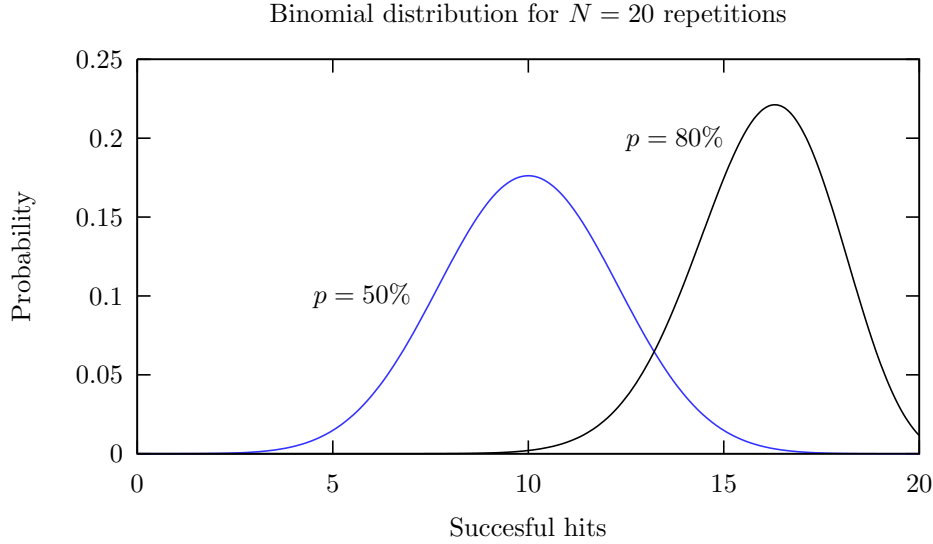


Figure 7: Binomial distribution showing the probability of different experimental outcomes for moderately effective detectors.

detector with an efficacy of  $p = 80\%$ . This distribution would yield an average of 18 successful hits with a standard deviation of 1.8. Our experimental result is completely inconsistent with even this moderate efficacy, being more than 8 standard deviations away from the mean, with a probability of less than  $10^{-9}$ . Even if the efficacy of the detector were as low as  $p = 50\%$  (Fig. 7), the probability of having obtained only three successful hits would be a mere  $b(0.5, 3, 20) = 0.1\%$ .

The results may be summarized by Fig. 8 which displays the likelihood  $b(p, 3, 20)$  that the detector has an efficacy  $p$  normalized to its maximum value  $b(3/20, 3, 20)$ . The figure shows that the normalized likelihood of a completely ineffective detector, behaving in a completely random fashion with  $p = 1/8$  is quite high, 0.95, while the likelihood of any value  $p \geq 0.5$  is negligible, less than 0.005, and a rapidly decreasing function of  $p$ . This is made evident in Fig. 9, where the likelihood is plotted in a logarithmic scale.

To compare the actual search results with those expected from a fully random search, the operators had been asked to flip a coins three times and register the corresponding results in a specific column within the table of results (Fig. 5). Unfortunately, the result of the coin flips (only one successful hit out of twenty tries) was worse than that of the detector, so that, although perfectly compatible with chance (we would expect this result in one out of five repetitions of the complete test, as shown by Fig. 6), its comparison to the detector performance lacked impressiveness.



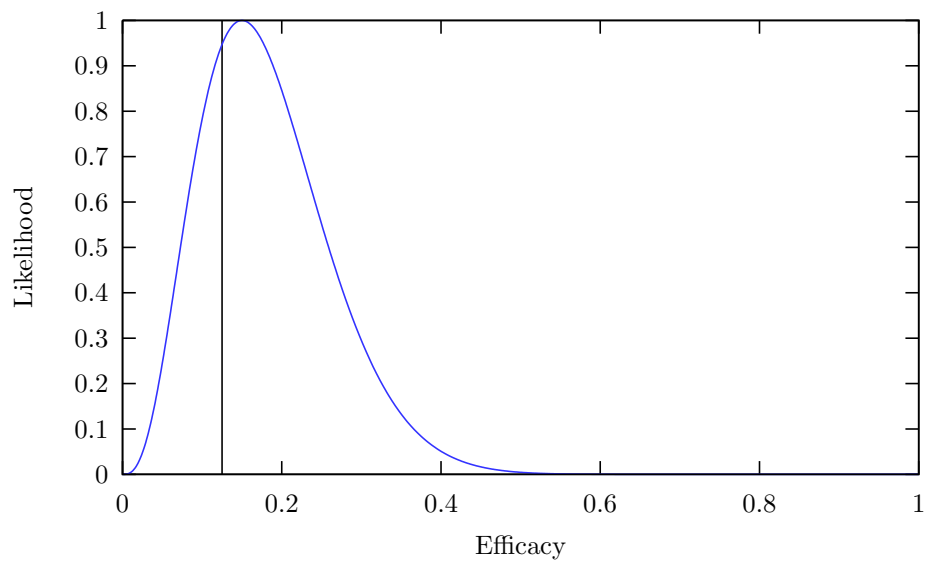


Figure 8: Likelihood of the detector having an efficacy  $p$  given the experimental result of 3 successful hits out of 20 tries. The vertical line corresponds to complete randomness,  $p = 1/8$ .

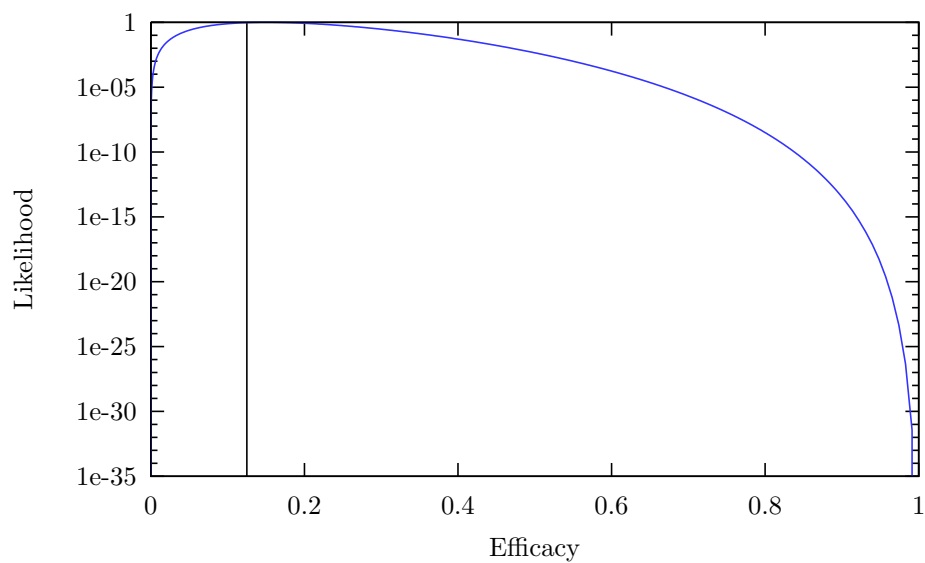


Figure 9: Likelihood of the detector having an efficacy  $p$ , as in Fig. 8, but displayed with a logarithmic vertical scale.

## 5 Conclusions

The test described in this paper allows us to conclude that the GT200 proved completely *ineffective* as an instrument to detect the substances and munitions used as the sample when the operator ignores beforehand where the substance has been hidden. It is important to note that its manufacturer and its users have claimed that the GT200 detects and identifies nanograms, and even picograms, of hundreds of substances such as manifold drugs and explosives from distances as far away as hundreds or even thousands of meters while hidden in presumably unknown locations, while, in this test, we used more than a kilogram of pills containing about 50g of the stimulant drug Clorobenzorex, as well as four bullets. They were known to be hidden in one out of eight boxes, and the operators were free to explore from distances not larger than 100m and to approach the boxes as close by as desired. It is also important to remark that the sample employed in this test had purportedly been previously detected within a house from its outside and forms part of the *evidence* being currently employed against its dweller, accused of illegal drug dealing. During this test, the GT200 picked consistently the correct location of the sample only when its operators knew beforehand where it was hidden; when they didn't, *the GT200 failed absolutely and threw results fully consistent with a random choice*. Thus, the GT200 is necessarily manipulated by its user to point towards the location where he expects the sample to be hidden, although he may be unaware of this manipulation. The GT200 itself provides no information about the location of the sample, even when used by trained and certified operators. Thus, *we conclude that the GT200 is worthless as a substance detector*.

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